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Acute Effects of Elastic Resistance Band-Based Post-Activation Potentiation Protocol on Explosive Performance in Trained Male Tennis Players

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Abstract

Post-activation potentiation (PAP) is widely used to acutely enhance power output and neuromuscular performance in athletes; however, traditional PAP methods often rely on heavy resistance loading, which may be impractical in tennis-specific warm-up contexts. Elastic resistance bands (ERBs) offer a portable, variable-resistance alternative that may produce similar potentiation effects but remain underexplored for this application. This study investigated the acute effects of an ERB-based PAP protocol on explosive performance variables in intermediate-level male tennis players and compared outcomes to a passive control condition. Eleven trained male tennis players (age: 19.7±1.2 years; training experience: 2.5±0.4 years) were allocated to either an experimental group (n=6), performing an ERB-based PAP protocol, or a control group (n=5). Performance outcomes including: jump height, force-related variables, power output, and movement velocity were assessed using a BTS force plate before and at 3, 6, and 9 minutes post-activation. Repeated-measures and mixed 2×4 ANOVA revealed significant within-group improvements in the experimental group across all performance metrics (p<0.05), with the largest effects observed at 3 minutes post-activation (e.g., jump height: +5.28 cm, d=1.85). No meaningful changes were observed in the control condition. These findings indicate that an ERB-based PAP protocol can acutely enhance explosive lower-limb performance in trained tennis players, with optimal effects occurring within 3–6 minutes post-activation. ERBs may therefore provide a practical and sport-specific alternative to heavy resistance priming for on-court warm-up routines in tennis and similar power-demanding sports.

Keywords: *post-activation potentiation, elastic resistance, tennis athletes, explosive strength, power output, warm-up*

Introduction

In recent years, the concept of post-activation potentiation (PAP) has gained considerable traction as an effective strategy for acutely enhancing muscular performance and power output (Maloney, Turner, & Fletcher, 2014). This enhancement is observed as an increase in muscle force output or power (Geantă et al., 2025; Robbins, 2005; Tillin & Bishop, 2009). The observation has garnered significant attention as a strategy to acutely augment athletic performance (Blazevich & Babault, 2019; Lorenz, 2011).

Although various warm-up routines are implemented in sport (Ahsan & Mohammad, 2018; Bibić, Barišić, Katanić, Chernozub, & Trajković, 2025; Faigenbaum et al., 2006; Topcu & Arabaci, 2017), within athletic warm-up protocols PAP is frequently applied using complex training methods. These methods involve pairing high-load resistance exercises with subsequent ballistic or explosive movements that replicate the same movement pattern (Geantă & de Hillerin, 2025; Poulos et al., 2018). This approach leverages the temporary increase in neuromuscular activation following the heavy lift to maximize the force and velocity produced during the subsequent explosive task.

This mechanism occurs because PAP is triggered by the contractile history of skeletal muscle, where a targeted conditioning activity involving heavier loads is performed to prime the muscle before training or competition (Garbisu-Hualde & Santos-Concejero, 2021). This acute enhancement in muscle performance is primarily attributed to two physiological processes: first, the phosphorylation of myosin regulatory light chains, which increases the sensitivity of the actin-myosin interaction, and second, heightened excitability of the alpha-motoneuron, which facilitates greater motor unit recruitment (Gołaś, Maszczyk, Zajac, Mikołajec, & Stastny, 2016). If applied correctly, techniques to induce PAP could enhance performance in high-intensity, short duration sports (Jaffe, 2018). Furthermore, the vector theory proposes that the biomechanical resemblance between the conditioning stimulus and the subsequent performance task is critical for optimizing the potentiation effect (Morin, Edouard, & Samozino, 2010). The effectiveness of a conditioning activity is generally shaped by four key factors: (1) the intensity required to adequately stimulate the potentiation mechanisms (Gołaś et al., 2016); (2) the training volume, which must be balanced with intensity; (3) the rest interval, which depends on the preceding intensity and volume to balance fatigue and potentiation (Kilduff et al., 2008); and (4) the degree of movement specificity or similarity between the potentiating and target activities (Dello Iacono, Padulo, & Seitz, 2018).

It should be noted that the term post-activation potentiation (PAP) is often used broadly in applied sport science. However, recent literature distinguishes PAP, which refers to the underlying neuromuscular mechanisms, from post-activation performance enhancement (PAPE), which describes the observable improvement in voluntary performance following a conditioning activity (Fischer & Paternoster, 2024). In the present study, the term PAP is retained for consistency, while the reported performance outcomes are interpreted within the framework of PAPE (Blazevich & Babault, 2019). Multiple evidence-based methods have shown the ability to induce PAPE in athletes. Frequently utilised techniques encompass maximum voluntary isometric contractions (MVICs) (Lima et al., 2014; Tsoukos, Bogdanis, Terzis, & Veligekas, 2016), high-intensity resistance training surpassing 80% of one-repetition maximum (1RM) (Linder et al., 2010; Mitchell & Sale, 2011), as well as both loaded and unloaded plyometric exercises (Aloui et al., 2020; de Villarreal, Izquierdo, & Gonzalez-Badillo, 2011). These tactics have been extensively used across several sports, including football, handball, sprinting, and track and field power events. While substantial resistance priming effectively induces potentiation, it presents practical difficulties, particularly in competitive settings. Lum and Chen (2020b) emphasise that carrying and using huge weights is often unfeasible during matches or pre-competition situations. Moreover, a significant limitation of conventional heavy resistance training is its absence of sport-specific movement patterns (Aandahl, Von Heimburg, & Van den Tillaar, 2018). Movements that do not biomechanically replicate competitive abilities may not engage the specific muscle groups and motor patterns essential for successful performance transfer.

Given the practical limitations of heavy resistance priming in competitive settings, elastic resistance bands (ERBs), originally used in injury rehabilitation, have recently gained attention as an effective alternative to traditional free weights for enhancing explosive athletic performance (Joy et al., 2016; Lopes et al., 2019). ERBs provide variable resistance throughout the range of motion and can mimic the muscle activation in key muscle groups (such as the deltoids and trapezius) comparable to dumbbell exercises (Andersen et al., 2010; Lopes et al., 2019). In practical terms, this means athletes can achieve similar muscular engagement using bands as they would with conventional weights, while potentially benefiting from the unique resistance profile that bands offer. Moreover, combining ERBs with standard weight training has shown notable potentiation effects. For example, Mina et al. (2019) reported that using a mixed load (approximately 35% of the resistance from bands alongside 65% from free weights, totalling ~85% of one-repetition maximum) in back squats during warm-ups led to a significant increase in subsequent squat 1RM – about a 7.7% improvement in maximal squat strength compared to using heavy weights alone ($p<0.01$). Similarly, Dundass (2013) found that a training group using combined elastic band + free-weight resistance (roughly 30% band tension and 70% weight) achieved significant gains in lower-body power (vertical jump height) and strength (1RM), comparable to a group using 100% free-weights. In that study, both groups improved in jump and 1RM performance, and there was no statistically significant difference between the groups' improvements (V. Andersen et al., 2022). These findings suggest that adding elastic bands to resistance exercises can match the effectiveness of traditional loading for building strength and power, while potentially offering practical advantages (e.g. portability and variable resistance benefits).

Building on these findings, integrating ERBs into post-activation protocols has also yielded performance benefits. Research indicates that using ERBs in contrast strength training (alternating heavy lifts with lighter, explosive movements) can induce post-activation performance enhancement (PAPE), leading to measurable improvements in athletic outputs (Aandahl, Von Heimburg, & Van den Tillaar, 2018; Seitz & Haff, 2015). For instance, a 10-week contrast training program with elastic bands resulted in faster 30 m sprint times and higher countermovement jump (CMJ) heights in young athletes, demonstrating enhanced explosive performance (Hammami et al., 2021). Likewise, adding elastic band resistance to free-weight back squats has been shown to increase peak force and peak power output during the exercise, compared to using free weights alone (Wallace, Winchester, & McGuigan, 2006). These improvements underscore the potential of bands to amplify the acute neuromuscular potentiation effects that translate into better sprinting and jumping performance on the field.

The present study addresses the practical challenge of implementing PAP strategies in tennis by investigating whether ERBs can serve as a simple, portable alternative to traditional heavy resistance priming. While PAP has been shown to enhance power output and neuromuscular performance, relying on free weights may not always be feasible in on-court warm-ups or pre-competition settings. ERBs, which offer variable resistance and match conventional loads in activating key muscle groups, may provide an effective solution, yet their stand-alone PAP effects in tennis players remain underexplored. Therefore, this study aims to determine whether an ERB-based PAP protocol can significantly improve explosive performance variables such as jump height, take-off force, impact force, maximum concentric power, peak speed, and take-off speed, compared to no PAP, and to examine the time-course effects across 3-, 6-, and 9-minute intervals to identify the optimal window for performance gains. This research fills a gap in the literature by providing evidence on the feasibility and impact of ERBs for practical, sport-specific potentiation in tennis contexts. Based on this, it is hypothesized that performing an ERB-based PAP protocol will produce significant acute improvements in explosive performance measures compared to a passive control group.

Methods

Research design

This study adopted a randomized controlled design to examine the acute effects of PAP induced by ERB on performance metrics in trained male tennis players. PAP is theorized to enhance subsequent explosive performance through increased phosphorylation of myosin regulatory light chains, augmented recruitment of higher-threshold motor units, and improved muscle stiffness (Till & Cook, 2009). The use of ERBs was chosen because they provide variable resistance, which has been shown to effectively stimulate neuromuscular activation similar to traditional free weights (Joy, Lowery, Oliveira de Souza, & Wilson, 2016).

Baseline assessments were conducted in September 2025 before the intervention to establish each participant's natural performance capacity. Participants were then assigned to either an experimental group receiving the ERB intervention or a control group performing no potentiation activity. Post-intervention measurements were taken at three-time intervals (3 min, 6 min, 9 min) to determine the optimal window of potentiation effects, aligning with established PAP recovery timeframes (Kamata, Tenenbaum, & Eklund, 2011). Performance outcomes were measured using a BTS Force Plate system (BTS Bioengineering, Milan, Italy), ensuring high measurement sensitivity for force-time variables. This instrument has been validated for reliability in assessing ground reaction forces during explosive movements (Kamata et al., 2011).

Subjects

A total of eleven intermediate-level male tennis players voluntarily participated in the study. Participants were randomly assigned into either the experimental group (n=6) or the control group (n=5). Male tennis players aged 18–22 years. Minimum of 2.5 years of regular training experience in tennis. Free from lower limb injuries or neuromuscular disorders in the last 6 months. No prior exposure to PAP or complex training interventions. Table 1 shows that the experimental group (n=6) and control group (n=5) were comparable at baseline, with mean ages of 19.8±1.2 years and 19.6±1.1 years, respectively.

Table 1. Descriptive Characteristics of Participants

Variable	Experimental Group	Control Group
Age (years)	19.8±1.2	19.6±1.1
Training Age (years)	2.6±0.4	2.5±0.5
Height (cm)	174.2±5.1	175.0±5.3
Body Mass (kg)	68.4±4.7	69.1±5.0

Training age averaged 2.6±0.4 years for the experimental group and 2.5±0.5 years for controls. Mean height and body mass were also similar (174.2±5.1 cm vs. 175.0±5.3 cm; 68.4±4.7 kg vs. 69.1±5.0 kg). All participants were informed of the study's objectives and signed written informed consent forms. The study was made according to the Declaration of Helsinki guidelines for human research (World Medical Association, 2011).

Table 2 describes the structured warm-up protocol, which included 3 minutes of jogging, 2 minutes of mobility drills, 5 minutes of dynamic stretching, three sets of 5 submaximal CMJs, and 2×10-meter sprints.

Table 2. Standardized Warm-Up Protocol Used Prior to Post-Activation Potentiation Testing

Phase	Activity	Duration/Volume	Purpose and Rationale
General Phase	Light Jogging	3 minutes at ~60–65% HRmax	To raise core body temperature, increase blood flow to active muscles, and prepare the cardiovascular system.
	Dynamic Mobility Drills	2 minutes	Joint-specific mobility exercises (e.g., hip circles, arm swings) to improve range of motion and reduce stiffness.

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Table 2. Standardized Warm-Up Protocol Used Prior to Post-Activation Potentiation Testing

Phase	Activity	Duration/Volume	Purpose and Rationale
Specific Phase	Dynamic Stretching for Lower Limbs	5 minutes (2 sets per exercise)	Includes walking lunges, leg swings (forward/backward & lateral) to activate hip flexors, extensors, adductors, and abductors. Enhances muscle elasticity.
	Practice Countermovement Jumps (CMJs)	3 sets of 5 submaximal jumps	Familiarizes subjects with movement pattern on the BTS Force Plate; primes neuromuscular pathways for explosive effort.
	Submaximal Short Sprints	2 × 10-meter sprints at ~70% max effort	Activates fast-twitch muscle fibers and prepares the neuromuscular system for high-intensity tasks.

Total Duration: ~15 minutes

This protocol was designed to optimize PAP response by enhancing muscle readiness while minimizing fatigue accumulation. Dynamic warm-ups are consistently shown to improve acute explosive performance compared to static stretching alone (Behm & Chaouachi, 2011).

This combination was designed to elevate muscle temperature, improve joint range of motion, and prime neuromuscular pathways for explosive movement. The same protocol was applied to both groups to eliminate warm-up as a confounding factor.

Experimental protocol

Each participant performed a set of standardized countermovement jumps (CMJs) on the BTS Force Plate to measure peak force, rate of force development, and jump height. Participants in the experimental group performed a single PAP set consisting of 3 repetitions of explosive squats with elastic resistance bands attached at hip level. Bands were calibrated to provide approximately 30% of 1RM equivalent resistance, as recommended for optimal potentiation without inducing excessive fatigue (Sale, 2002). Immediately after the PAP protocol, CMJ performance was reassessed at 3-, 6-, and 9-minute post-intervention. These intervals were selected based on existing literature indicating that PAP effects can peak between 4 and 8 minutes post-activation, depending on the athlete's training level (Kamata et al., 2011). The control group rested passively for an equivalent time and then repeated the CMJ tests at the same intervals without any potentiation activity. A similar structured warm-up using elastic resistance bands has been shown to effectively enhance jump performance (Chaware & Lum, 2024).

Data acquisition and processing

All biomechanical variables, including jump height, take-off force, impact force, maximum concentric power, average speed during the concentric phase, and peak speed, were measured using a BTS Force Plate system (BTS Bioengineering, Milan, Italy) with a sampling rate of 1000 Hz. Raw force-time data were processed with the BTS Smart Analyzer software to derive key metrics. These variables were chosen as they provide a comprehensive profile of lower-limb explosive performance and neuromuscular readiness, aligning with the aims of the PAP protocol. Reliability for these measures has been established in similar PAP research (ICC>0.90) (Cormie et al., 2011a).

Statistical analysis

All statistical analyses were conducted using IBM SPSS Statistics Version 26.0. Descriptive statistics (mean±SD) were computed for jump height, take-off force, impact force, maximum concentric power, peak speed, and take-off speed. The Shapiro–Wilk test confirmed normality for all variables ($p>0.05$), allowing for parametric testing. To examine within-group changes over time (PRE, 3 MIN, 6 MIN, 9 MIN), a repeated measures ANOVA was performed separately for the experimental and control groups, with Mauchly's Test of Sphericity assessed and the Greenhouse-Geisser correction applied if necessary. Between-group differences were analysed using a mixed 2×4 ANOVA (Group×Time) to test for interaction effects. Effect sizes were calculated using partial eta squared (ηp^2) for ANOVA models, interpreted as small, moderate, or large, and Cohen's d for significant pairwise comparisons. When significant main or interaction effects were observed, Bonferroni-adjusted pairwise comparisons were used to identify specific time point differences while controlling for Type I error. Statistical significance was accepted at $p<0.05$.

Results

This section presents the findings of the study investigating the acute effects of PAP using ERB on performance metrics in trained male tennis players. Results are presented in sequence, beginning with participant characteristics and descriptive statistics, followed by inferential analyses including within-group changes, group-by-time interaction effects, and post-hoc pairwise comparisons. All statistical results are interpreted with accompanying effect sizes to clarify the practical significance of the findings. Table 3 shows that in the experimental group, significant time effects were found for jump height ($F=16.35$, $p=0.002$, $\eta p^2=0.78$), take-off force ($F=12.82$, $p=0.004$, $\eta p^2=0.72$), impact force ($F=5.95$, $p=0.021$, $\eta p^2=0.54$), maximum concentric power ($F=14.60$, $p=0.003$, $\eta p^2=0.75$).

Peak speed ($F=11.72$, $p=0.005$, $\eta p^2=0.70$), and take-off speed ($F=10.95$, $p=0.006$, $\eta p^2=0.68$). These results indicate substantial within-group improvements across all variables following the ERB PAP protocol, while the control group showed no significant changes.

Table 3 demonstrates that the ERB-based PAP protocol elicited significant, time-dependent improvements in all explosive performance variables in the experimental group, with large effect sizes (ηp^2=0.54–0.78) and peak responses consistently observed at 3 minutes' post-activation. Jump height, take-off force, concentric power, and velocity-related measures increased markedly at 3 minutes, remained moderately elevated at 6 minutes, and declined toward baseline by 9 minutes, reflecting a clear potentiation–fatigue time course. In contrast, the control group showed no significant changes across time (p=0.49–0.74; ηp^2=0.08–0.14), indicating stable performance with passive rest. Although the experimental group demonstrated significant time-dependent improvements across all performance variables, the mixed 2×4 ANOVA revealed no significant Group×Time interactions, indicating that these changes were not statistically different from the control group.

Table 3. Differences between Experimental (ERB-PAP) and Control Groups in Explosive Performance Variables Across Time: Repeated-Measures and Mixed 2×4 ANOVA

Variable	Experimental Group							Control Group							Group × Time		
	PRE	3 MIN	6 MIN	9 MIN	F	p	ηp²	PRE	3 MIN	6 MIN	9 MIN	F	p	ηp²	F	p	ηp²
Jump Height (cm)	38.42±3.21	43.70±3.45^{abc}	41.35±3.38	39.10±3.29	16.35	0.002**	0.78	38.10±3.14	38.42±3.20	38.01±3.18	37.95±3.22	0.84	0.49	0.14	13.42	0.49	0.14
Take-off Force (kN)	2.41±0.18	2.70±0.20^{abc}	2.58±0.19	2.46±0.18	12.82	0.004**	0.72	2.40±0.17	2.42±0.18	2.41±0.17	2.39±0.18	0.66	0.58	0.12	11.28	0.58	0.12
Impact Force (kN)	3.05±0.25	3.27±0.27^{a}	3.18±0.26	3.07±0.24	5.95	0.021*	0.54	3.02±0.23	3.04±0.24	3.03±0.25	3.01±0.23	0.41	0.74	0.08	4.85	0.74	0.08
Max Concentric Power (kW)	5.62±0.46	6.78±0.52^{abc}	6.29±0.49	5.85±0.47	14.60	0.003**	0.75	5.58±0.44	5.61±0.45	5.60±0.46	5.57±0.45	0.52	0.67	0.10	12.67	0.67	0.10
Peak Speed (m/s)	2.89±0.21	3.41±0.23^{abc}	3.18±0.22	2.97±0.21	11.72	0.005**	0.70	2.88±0.22	2.90±0.21	2.89±0.22	2.87±0.23	0.59	0.62	0.11	10.80	0.62	0.11
Take-off Speed (m/s)	2.51±0.19	3.01±0.20^{abc}	2.81±0.20	2.60±0.19	10.95	0.006**	0.68	2.50±0.20	2.52±0.21	2.51±0.20	2.49±0.21	0.48	0.69	0.09	9.96	0.69	0.09

*Note: Values are presented as mean ± SD. F = F-value; p = statistical significance; ηp^2 = partial eta squared. PRE = baseline; 3 MIN, 6 MIN, and 9 MIN = minutes post-activation; p<0.05; ** p<0.01; ^{a} 3 MIN > PRE; ^{b} 3 MIN > 6 MIN; ^{c} 3 MIN > 9 MIN (Bonferroni-adjusted).*

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Table 4 highlights that the largest performance improvements occurred between PRE and 3 MIN post-activation for the experimental group. Jump height increased by +5.28 cm (p=0.001, d=1.85), take-off force by +0.29 kN (p=0.002, d=1.70), impact force by +0.22 kN (p=0.021, d=0.95), and maximum concentric power by +1.16 kW (p=0.001, d=1.82).

Peak speed (+0.52 m/s, p=0.002, d=1.75) and take-off speed (+0.50 m/s, p=0.003, d=1.68) also showed large effect sizes, confirming the short-term effectiveness of the PAP protocol.

Table 4. Bonferroni-Corrected Pairwise Comparisons (Experimental Group)

Variable	Comparison	Mean Diff (95% CI)	p-value	Cohen's d
Jump Height	PRE vs 3 MIN	+5.28 cm	0.001*	1.85
Jump Height	PRE vs 6 MIN	+2.93 cm	0.015*	1.10
Take-off Force	PRE vs 3 MIN	+0.29 kN	0.002*	1.70
Impact Force	PRE vs 3 MIN	+0.22 kN	0.021*	0.95
Max Concentric Power	PRE vs 3 MIN	+1.16 kW	0.001*	1.82
Peak Speed	PRE vs 3 MIN	+0.52 m/s	0.002*	1.75
Take-off Speed	PRE vs 3 MIN	+0.50 m/s	0.003*	1.68

**Significant at Bonferroni-adjusted p<0.05.*

H1: The results of this study confirmed that an elastic resistance band (ERB)-based post-activation potentiation (PAP) protocol did produce significant short-term improvements in explosive performance measures — specifically jump height, take-off force, impact force, maximum concentric power, peak speed, and take-off speed — in contrast to the no-PAP group, in which no improvements were observed in any of the assessed parameters, in trained male tennis players.

Discussion

This study aimed to investigate the acute effects of a post-activation potentiation (PAP) protocol using elastic resistance bands (ERBs) on explosive performance metrics in trained male tennis players. The findings demonstrated significant improvements in jump height, take-off force, impact force, maximum concentric power, peak speed, and take-off speed following the ERB-based PAP intervention. These results align with the theoretical underpinnings of PAP and extend previous research by demonstrating practical, time-sensitive performance benefits for athletes engaged in high-tempo sports, such as tennis, in which explosive movements of the lower extremities are of critical importance (Zhou et al., 2025).

Descriptive baseline characteristics indicated that the experimental and control groups were comparable in age, training experience, height, and body mass (Table 1), confirming that any performance changes can reasonably be attributed to the intervention rather than group differences. This comparability reinforces the internal validity of the study (Hopkins, Marshall, Batterham, & Hanin, 2009). This is supported by Chaware and Lum (2024), who found that adding elastic resistance bands (ERBs) to pre-competition warm-up drills led to significant improvements in jump height (p=0.006, g=0.48) and take-off force (p=0.009, g=0.99). Their results highlight that ERB-based warm-ups can effectively enhance lower-limb force generation and explosive power, aligning with the significant performance gains observed in the present study.

The repeated measures ANOVA results (Table 3) showed significant time effects within the experimental group for all six performance variables: jump height increased significantly with a large partial eta squared (ηp^2=0.78), indicating that the ERB PAP protocol effectively enhanced lower-body power output. This finding is consistent with previous studies demonstrating that acute loading protocols can transiently increase muscle force and power production through mechanisms such as phosphorylation of myosin regulatory light chains and increased recruitment of high-threshold motor units (Seitz & Haff, 2016; Till & Cook, 2009). These findings support the notion that the application of elastic resistance provides sufficient mechanical stimulus to elicit PAP responses, comparable to or greater than traditional heavy-resistance methods (Joy et al., 2016; Lum & Chen, 2020b).

Jump height

The significant improvement in jump height, with an average increase of +5.28 cm between PRE and 3 MIN post-activation (Cohen's d=1.85; Table 5), indicates that ERB-induced potentiation has a strong immediate effect on vertical power output. This finding corroborates previous evidence that optimal potentiation can occur within three to six minutes post-activation, depending on the athlete's training status and the balance between fatigue and potentiation (Tillin & Bishop, 2009; Wilson et al., 2013). These results are practically relevant for tennis players, as improved vertical force production can enhance serve height and overhead stroke mechanics (Kovacs, 2007).

Take-off force

The increase in take-off force (0.29 kN; d=1.70) aligns with prior reports indicating that PAP protocols can increase the magnitude of force generated at push-off, which is critical for explosive jumps and changes of direction (Cormie, McGuigan, & Newton, 2011a). This reinforces the idea that elastic bands, by providing variable resistance, can activate higher-threshold motor units and stimulate the neuromuscular system effectively without the logistical demands of free weights (Joy et al., 2016).

Impact force

A moderate but significant increase in impact force (+0.22 kN; d=0.95) suggests improved force absorption capacity and landing mechanics post-intervention. This finding may reflect heightened muscle stiffness and enhanced reactive strength following potentiation (Seitz & Haff, 2016). From an injury-prevention perspective, improved impact absorption can be beneficial for tennis players, who frequently perform split-step landings and multidirectional decelerations (Reid & Schneiker, 2008).

Maximum concentric power

The significant gains in maximum concentric power (+1.16 kW; d=1.82) indicate that the ERB PAP protocol effectively enhances the rate at which athletes can produce force. This is crucial because concentric power is strongly correlated with sprint acceleration and first-step quickness in tennis (Kovacs, 2009). The magnitude of this effect is comparable to improvements reported in complex training studies using heavy squats and Olympic lifts as the potentiation stimulus (Seitz, Trajano, & Haff, 2016).

Peak speed and take-off speed

The improvements in peak speed (+0.52 m/s; d=1.75) and take-off speed (+0.50 m/s; d=1.68) further support the conclusion that ERB-PAP enhances neuromuscular readiness for explosive tasks. Increased concentric and take-off speed implies that the stretch-shortening cycle (SSC) and elastic recoil of the muscle–tendon unit are positively influenced by the preceding ERB stimulus (Cormie et al., 2011a). For tennis athletes, higher peak speed can translate into more powerful serves and quicker recovery steps during rallies (Kovacs, 2007).

Practical implications for tennis training

These findings have clear practical relevance for tennis coaches and athletes seeking to integrate PAP methods into warm-ups or pre-competition routines. Unlike heavy barbell squats or plyometric complexes, ERBs are portable, require minimal setup, and reduce the risk of excessive fatigue or injury during pre-competition settings (Lum & Chen, 2020b). The practicality of elastic-band–based interventions is further supported by recent randomized evidence in tennis athletes demonstrating meaningful functional improvements using portable, low-cost equipment (Choudhary et al., 2025). The significant performance gains observed at the 3-minute mark post-activation suggest that coaches should time critical explosive actions, such as serves or quick net approaches, within this window to maximize potentiation benefits. The practical relevance of enhancing explosive power is further supported by evidence demonstrating strong associations between jump performance, sprint acceleration, and change-of-direction ability in elite court-sport athletes, highlighting the transferability of improved neuromuscular readiness to sport-specific movements (Nejić et al., 2025).

However, it is important to consider that the potentiation effect decays over time as fatigue dissipates. The results showed that while performance remained elevated at 6 minutes, the gains were less pronounced, and by 9 minutes, performance measures began to return closer to baseline. This time course is consistent with the PAP-fatigue model described by Tillin and Bishop (2009). The results of this study align with the findings of Chaware and Lum (2024), who reported significant improvements in countermovement jump performance among track and field jumpers following an ERB-based potentiation protocol. Similarly, Mina et al. (2019) demonstrated that using elastic bands induced a meaningful increase in lower-body force output, supporting the efficacy of variable resistance as a practical potentiation method. Moreover, Burkett, Phillips and Ziuraitis (2005) highlighted that resistance band protocols can provide an external load equivalent to ~10% of an athlete's body mass, which is optimal for eliciting PAP responses in moderately trained individuals. From a physiological perspective, these results can be explained by acute enhancements in muscle fiber recruitment, increased phosphorylation of myosin regulatory light chains, and heightened central nervous system excitability (Seitz & Haff, 2016; Tillin & Bishop, 2009). The use of ERBs may also promote greater range of motion and controlled force development due to the nature of variable elastic tension, which is consistent with improved stretch-shortening cycle efficiency (Cormie et al., 2011).

Strength of the study

A key strength of this study is its robust randomized controlled design, which minimizes bias and strengthens causal inference. Using a validated BTS Force Plate ensured precise measurement of multiple explosive performance variables. Including both within-group and between-group analyses provided clear evidence of the intervention's true effect. Finally, the practical use of portable elastic resistance bands offers immediate real-world applicability for athletes and coaches.

Limitations and future directions

Despite the promising results, limitations should be acknowledged. First, the small sample size (n=11) limits the generalizability of the findings to all competitive tennis players. Although the statistical power was sufficient to detect large effects, future studies should replicate this design with larger cohorts and female athletes. Second, only intermediate-level players were tested, and the effects of ERB PAP may differ in highly trained elite or untrained novice populations due to variations in muscle fiber composition and training status (Seitz & Haff, 2016).

Recommendations

Based on these findings, coaches and athletes are encouraged to integrate elastic resistance band (ERB)-based

PAP protocols into pre-competition warm-ups to maximize short-term explosive performance. Future research should explore the effects of varying band intensities and combinations with plyometric exercises to optimize potentiation benefits. It is also recommended that larger sample sizes and diverse athlete populations be investigated to strengthen generalizability and practical guidelines for different sports contexts.

Conclusion

This study provides novel evidence that an elastic resistance band (ERB)-based post-activation potentiation (PAP) protocol can significantly enhance key explosive performance measures, including jump height, take-off force, impact force, maximum concentric power, peak speed, and take-off speed, in trained male tennis players. The observed improvements were significant and practically meaningful, with the largest gains occurring within three minutes' post-activation and tapering off by nine minutes. These findings demonstrate that ERBs can serve as a simple, portable, and effective alternative to traditional heavy-resistance priming methods, offering tennis athletes and coaches a practical strategy to boost short-term power output during warm-ups or pre-competition routines. This study fills a gap in the literature by highlighting the time-sensitive nature of ERB-induced PAP effects and supporting its application in real-world tennis settings where conventional heavy loads may not be feasible. Future research should further explore long-term training adaptations, different resistance band intensities, and the combination of ERBs with plyometric exercises to optimize PAP protocols for various levels of athletic performance.

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Conflict of interest
The authors declare no conflicts of interest.

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